SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

More sustainable European cattle systems – a virtual handbook

Photo: Annika Arnesson

Editor: Håvard Steinshamn

The SusCatt project was possible by funding from SusAn, an ERA-Net, co-funded under European Union's Horizon 2020 research and innovation programme (www.era-susan.eu), Grant n°696231, including contributions from the Research Council of Norway (RCN, Norway), the Swedish Research Council (FORMAS, Sweden), Department for Environment, Food & Rural Affairs (DEFRA, UK), Ministry of Agricultural, Food and Forestry Policies (MiPAFF, Italy), National Centre for Research and Development (NCBR, Poland), The Federal Ministry of Food and Agriculture (BMEL, Germany).

TECHNICAL NOTE

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Introduction to SusCatt Technical Notes and Handbook on Sustainable European Cattle Production

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In **SusCatt**, we conducted surveys and experiments to improve productivity, environmental impact and consumer's acceptability from a transition to high forage and pasture diets for our cattle. However, the outcome of this research will only be successful in practice, if picked up and implemented on a large scale. Thus, an effective dissemination strategy, providing suitable messages in appropriate formats, is essential for optimum uptake of SusCatt deliverables and innovations by European industries, other stakeholder groups and delivering information to policy makers and consumers. Our findings will only improve the sustainability of European cattle in practice if widely adopted, possibly supported by educated consumers creating a demand for more sustainable dairy and beef products.

As academics we are used to communicating with the scientific community via publications in peer reviewed journals or presentations at conferences. The main objective for work package 5 and our dissemination was to broaden communication beyond academia to reach farmers, others involved in the livestock industry, policy makers, diet related health professionals and consumers. To this end we have prepared the 20 technical notes and information sheets covering a wide range of the tasks from SusCatt, now compiled into this virtual *Handbook*. In the list below, each title will link to the appropriate note on the SusCatt website.

Work Package 2 Beef production

TASK 2.1 Cross- and purebred steers on pasture
Performance and carcass traits of beef-cross and pure-bred dairy steers on forage and semi-natural pastures

Dairy cow wearing a RumiWatch halter. Photo: Gillian Butler

TASK 2.1 Eating quality of meat from steers
Eating quality of meat from beef-cross and pure-bred dairy steers reared on forage and semi-natural pastures

TASK 2.1 Profitability of steers on forage based diet
Profitability of dairy and dairy × beef breed steers in beef production based on forage and semi-natural pastures

TASK 2.2 Performance and carcass traits of dairy and beef × dairy bulls in forage-based beef production
Using Angus semen on dairy cows gives bull calves with a potential for higher growth, carcass weights and better carcass characteristics regardless of feed intensity

TASK 2.2 Eating quality of meat from dairy and beef × dairy bulls in forage-based production
A high proportion of Swedish beef comes from dairy cows. Crossing cows with beef breeds increases the value of calves and subsequent carcasses and might impact beef quality

TASK 2.2 Profitability of dairy and beef × dairy bulls in forage-based beef production

Using beef rather than dairy semen for dairy cows is a good choice for profitability on farms with facilities for indoor, forage-based feeding

TASK 2.3 Sustainability factors of the Italian beef rearing system

We investigated if more home-grown forages and by-product feeds for intensive beef can maintain good performance, ensure health and welfare and reduce environmental impact

TASK 2.3 Maize silage for beef cattle: good or bad? Health traits of dualpurpose crossbreeds and pure beef cattle

Most beef in Italy is from specialised farms, importing young beef bulls. Cattle are fed concentrates diets dominated by maize silage and grain. Here we discuss the health impact for two beef breeds

TASK 2.4 Better nutritional quality in grass-fed milk and meat

TASK 2.4 Nutritional quality of pasture-fed beef

SusCatt adds to evidence on the superior nutritional quality of products from extensive farming, especially from forage only feeding which could potentially cut deficiencies in long chain omega-3 fatty acids consumption.

Work Package 3 Dairy production

TASK 3.1 Selecting for Efficiency in Pasture-Based Dairying

Pasture-based dairying relies on conversion of grazing into milk while cows maintain body condition, health and fertility. Individual cows are consistently more efficient and could breed replacements to maintain and improve grazing conversion efficiency

TASK 3.1 Which cows suit UK low-input or organic dairying?

UK interest in grazing-based dairying has recently increased, yet there is little guidance on breeding priorities, with farms selecting cows to suit their system. Here we describe lessons from 17 such farms

TASK 3.2 Improving permanent pastures

Permanent pastures can support good production if well managed but are often neglected or misused. This note describes successful pasture renovation without pesticide application, by cross under-sowing with a direct drill fitted with a tine cultivator proved.

TASK 3.2 Improving milk output from permanent grassland

Pasture establishment and growth were successful initially, leading to higher milk output. However, atypical drought causing poor herbage growth and quality confounded results in year 2 with cow grazing unimproved pasture giving more milk. Further monitoring is needed.

TASK 3.3 Does it matter how much forage our dairy cows eat?

Farms in Central Norway, feeding more forage to dairy cows, achieved lower yield per cow but higher profitability than farms feeding more concentrates. The Global warming potential of farms was independent of concentrate use.

TASK 3.4 Sustainability factors of Italian dairy system

If we are to improve the production efficiency and environmental sustainability of Italian animal farming, with full regard to animal health and welfare, we need to identify what strategies and changes are appropriate - system analysis is crucial, especially for the dairy sector

TASK 3.4 What do our cows eat? - Using technology to authenticate forage-based milk

Declaring feeding regime is not mandatory for dairy products. However, both geography and production intensity influence product quality and consumers should be able to identify sustainable, animal-friendly product lines

TASK 3.5 Forages to reduce the environmental impact of grazing dairy cows

If managed efficiently, diverse pasture with legumes and herbs outperformed simple swards in milk yield and achieved low methane emissions

Work Package 4 Assessment

TASK 4.4 Building the market for Grass-fed

Beef and Dairy are hot-topic with negative associations for many consumers. However, not all products are the same and evidence supports many benefits grass-fed, but how can we encourage its production and consumptions?

Imprint

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Performance and carcass traits of beef-cross and pure bred dairy steers on forage and semi-natural pastures

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About

We are faced with a dilemma - grazing is necessary to maintain biodiversity in semi-natural pastures, but cattle contribute to climate change.

Could steers born into dairy herds offer grazers a lower climate opportunity, without compromising performance and carcass traits?

We compared the performance of beef-cross and pure-bred dairy steers in two forage and pasture-based production systems.

The steers were raised at SLU Götala Beef and Lamb Research Centre. Photo: Anna Hessle.

Objective

The effect of using beef semen on dairy cows has the greatest impact in intensive rearing systems where the growth potential of crossbred cattle can be efficiently utilized. This study investigated if these crossbred steers also performed better than pure-bred dairy calves in extensive systems based on forages and grazing semi-natural pastures.

What did we do?

In the experiment, the performance of 32 pure-bred Swedish Red or Swedish Holstein dairy steer calves were compared with 32 Charolais cross steers from Swedish Red or Holstein cows – all at two feeding levels. Sixteen calves from each group were fed at a moderately high intensity and these were compared with 16 from each group fed a lower intensity diet.

The high feed groups of spring-born calves started inside on early harvested grass/clover silage supplemented with barley, peas and rapeseed meal, initially composing 42 % of diet. Concentrate decreased along with increased animal weight to 0 % at turn-out to semi-natural pastures. Steers finally were finished inside on early harvested silage, for slaughter at 21 months of age.
The low intensity autumn-born calves had a shorter initial housing period followed by grazing semi-natural pastures after turnout. During winter housing, they ate late cut silage before spending a second summer on semi-natural pasture. They were housed for final finishing on early cut silage and slaughtered at 28 months of age.

They were followed throughout life, to slaughter and cutting, weighing sections from one hindquarter of each animal.

Compare right weight gain

Growth rates for the cross bred and pure bred calves throughout life were similar at 0.85 kg per day. However, after slaughter we could confirm the superiority of the crossbreds with greater carcass weights. For steers slaughtered at 21 months of age, their carcasses were on average 32 kg higher compared to pure-bred dairy steers. For steers slaughtered at 28

months of age, the breed difference was even greater at 50 kg. So, one should not be fooled by just looking at the liveweight, as it is the composition of the weight gain that matters and effects the carcass weight.

More muscles in crossbreds

There were also differences in their deposition of muscles and fat, with a greater proportion of muscles found in the beef crosses than dairy bred steers. Again, difference in conformation score between the breed groups in our study were greater for steers slaughtered at 28 months of age than for those slaughtered at 21 months. Furthermore, the higher conformation score of the crossbreds was reflected in a larger proportion of valuable retail cuts and a smaller proportion of bone in the carcasses. The dairy steers deposited more fat, reflecting a tendency to a higher degree of visually assessed intramuscular marbling, in the sirloin steak. However, these differences in fat class or fat trim between the breeds proved not to be statistically significant.

More fatness with longer finishing

The steers slaughtered at 21 months of age had a higher fat class than cattle slaughtered at 28 months. This is possibly a reflection on the longer housing period of the 21-month-steers leading up to slaughter (163 vs 100 days) since growth rates were greater on silage compared with grazing. Normally, the proportion of carcass fat is higher from bigger cattle, but here we found fatter carcasses from animals with lower carcass weight maybe because a higher weight gain during finishing phase.

Cross bred steers had heavier carcasses with more muscles than pure dairy steers. Photo: Frida Dahlström.

Conclusion

Using beef breed semen for dairy cows gives calves with the potential for higher carcass gain and more meat compared with pure-bred dairy cattle – even under semi-intensive and extensive forage based systems.

Half of the steers were grazing two summers on semi-natural pastures before slaughter at 28 months of age. Photo: Vanja Sandgren.

Foreman Jonas Dahl took care of the steers whereas associated professor Anna Hessle was responsible for the research. Photo: Vanja Sandgren.

Imprint

Citing: Hessle, A., Therkildsen, M., Segerkvist, K. (2019). Beef production systems with steers of dairy and dairy x beef breed based on forage and semi-natural pastures. Animals 9, 1064. Download at https://www.mdpi.com/2076-2615/9/12/1064. SusCatt Technical note 2.1.1 Download at https://bit.ly/2GT1OHF

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Eating quality of meat from beef-cross and pure bred dairy steers reared on forage and semi-natural pastures

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About

We know cattle contribute to climate change, but they also have an invaluable role in maintaining biodiversity, amenity and recreation value of semi-natural pastures. This project considered how extensive rearing of pure and crossbred dairy steers using semi-natural pasture influenced meat quality.

Objective

Crossing dairy cows with beef bulls can give calves a higher growth potential than purebred dairy calves. Here we assess how rearing both types of calf, under semi-intensive or extensive systems, affect the eating quality of the meat produced.

What did we do?

The study compared 32 pure-bred Swedish Red or Swedish Holstein dairy steer calves with 32 Charolais cross steers from Swedish Red or Swedish Holstein cows – under two different production systems. All cattle grazed semi-natural pasture in the summer and 16 calves from each breed were fed at moderately high intensity when housed in winter and slaughtered at 21 months giving approximately 300 kg carcass weight. These were compared with 16 calves from each breed, fed at lower intensity during the winters - slaughtered at 28 months of age and 330 kg carcass weight. More details of the rearing are in SusCatt technical note 2.1.1.

Animals were followed from birth through to carcass cutting. After slaughter, carcass pH and temperature decline were measured and the strip loin (M. longissimus dorsi) was sampled to assess technological characteristics (tenderness, water holding capacity and colour), fatty acid composition and sensory attributes. All meat was aged for seven days then frozen before analysis.

The younger, semi-intensively reared steers gave more tender meat than the older, extensively reared. Photo: Vanja Sandgren.

Small differences in technological meat

Ideally meat ought to reach pH 5.7 or lower, if tenderness is not to be compromised. Although meat from the older, extensively reared animals, ended up at a lower pH than meat from younger, semi-intensively reared steers, both had good pH values. Nevertheless, the cutting resistance, or force required to cut through a defined piece of meat, was generally high, suggesting the need for more than seven days aging for these types of systems. As expected, meat from the older steers was slightly darker than meat from younger ones, otherwise there were no other differences between meat quality parameters measured.

Young dairy steers the sensory favourite

Even though the technological assessment revealed little difference, either between breeds or production systems, sensory tests showed meat from beef crosses had poorer eating quality compared to purebred dairy

steers; with a coarser fibre structure and less intense red colour. Further, meat from the crossbred steers was less tender, assessed as cutting and chewing resistance, less juicy and perceived as having a more sour flavour.

The younger, more intensively, reared animals produced meat with a less intense red colour that was considered more tender than meat form the older, extensively reared steers, i.e. required less force to cut and chew. Interestingly, they also gave meat with a more intense game flavour.

More unsaturated fat in older animals

The healthiness of beef for consumers has long been discussed in relation to its content of saturated fat. Even though the negative effects of saturated fatty acids on different conditions have been questioned, it is desirable to improve the fatty acid profile of beef by increasing the proportion of polyunsaturated fatty acids, especially omega-3 fatty acids.

In this study, we could see a higher proportion of unsaturated fatty acids in meat from older, extensively reared animals, which was also reflected in more omega-3 fatty acids. An interesting finding was that meat from the crossbreds contained a higher proportion of polyunsaturated fatty acids than meat from the pure dairy steers.

Conclusion

Meat from younger, semi-intensively reared animals, regardless of breed, was more tender than meat from older, extensively reared animals. Further, meat from beef crosses had poorer eating quality than purebred dairy steers, due to coarser fibre structure, less tenderness and juiciness. However, the fatty acid profile was preferable from the crossbreds with a higher proportion of polyunsaturated fatty acids.

Karin Wallin takes samples of a loin for meat quality analysis. Photo: Frida Dahlström.

Meat from these type of systems need more than seven days aging for optimal tenderness. Photo: Frida Dahlström.

Imprint

Citing: Arvidsson-Segerkvist, K. (2020) Eating quality of meat from beef-cross and pure bred dairy steers reared on forage and semi-natural pastures. SusCatt technical note 2.1.2. Download at https://bit.ly/2GT1OHF

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Profitability of dairy and dairy × beef breed steers in beef production based on forage and semi-natural pastures

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About

Could steers born into dairy herds offer grazers a profitable climate-friendly opportunity to maintain biodiversity? We compared the economics of pure-bred dairy and beef-cross steers under two forage and pasture-based production systems, in three Swedish regions covering a range of conditions for forage, pasture and grain production.

Objective

The income from steer beef is a combination of slaughter income, agri-environmental payments and other support. This study investigated if crossbred steers had an increased profitability compared to pure-bred dairy calves in two different production systems based on forages, grazing more or less semi-natural pastures, and access to more or less agri-environmental payments and supports.

What did we do?

The study was based on a trial reported in SusCatt technical note 2.1.1. Steers of two breed combinations (dairy vs. dairy x beef) were compared in two forage feeding systems. The first one included moderately high indoor feed intensity, one summer on grass and slaughter at 21 months of age, whereas the other system meant low indoor feed intensity, two summers on grass and slaughter at 28 months of age. An enterprise budgeting technique used data from the original all-in-all-out system to assess profitability of continuous rearing, assuming calves were born throughout the year. Profitability was assessed for three different geographical Swedish regions;

1. plain district (PD) of southern Sweden, no less-favoured area (LFA) support and steers grazing grass ley.
2. forest district (FD) of southern Sweden, situated in a LFA, where steers solely grazed semi-natural pastures.
3. northern Sweden (ND) within LFA, where the steers grazed 20% semi-natural pastures and 80% ley.

The author Kristina Holmström with her study objects. Photo: Anna Hessle.

All semi-natural pasture was assumed at 70% land rendering agri-environmental payment at a basic level (100 Euro/ha) and 30% of high biological values, eligible for a higher agri-environment payment (280 Euro/ha). In addition to basic calculations, sensitivity analyses were conducted to allow using existing building without an alternative profitable use and if agri-environmental payments and support were 20% lower than present.

Higher income from older steers

The enterprise budgeting calculations showed that choice of production system influenced incomes more than the breed combination. Older, heavier steers, grazing over two seasons, generally gave higher revenue compared to younger and lighter steers, only grazing one season. Interestingly, in the two LFA eligible regions, payments from agri-environment aid and supports were almost as high as that from the carcasses, especially for the older steers.

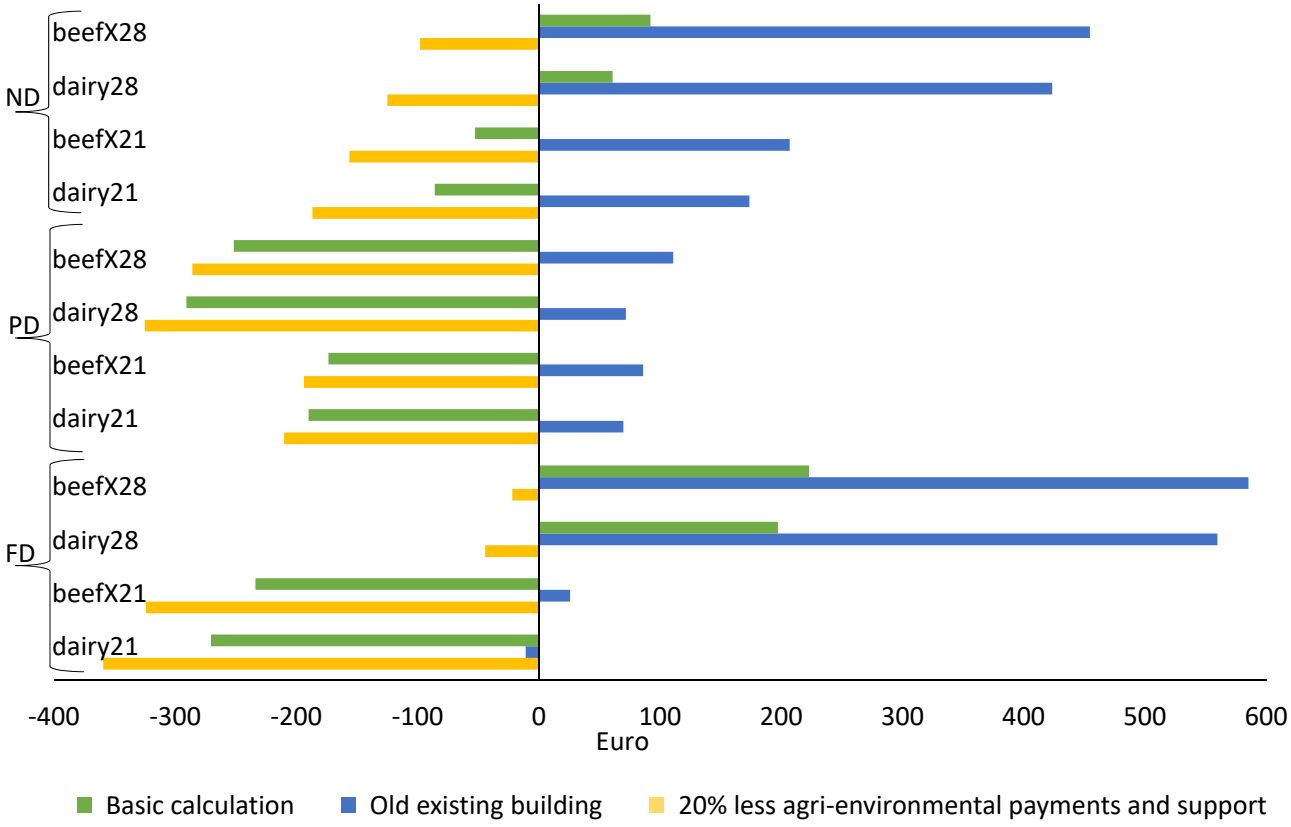

Figure. Basic calculations and sensitivity analysis for profitability (Euro/steer) of purebred dairy steers (dairy) and dairy-beef crossbred steers (beefX) reared at a moderately high feed intensity and slaughtered at 21 months of age (21) or at a low feed intensity with slaughter at 28 months of age (28), in plain district (PD), forest district (FD) and northern district (ND) of Sweden.

Small differences in costs

The largest cost was for silage, followed by labour, calf purchase and buildings. There were only relatively small differences between the twelve rearing combinations tested. However, there was a difference in cost between breeds when purchasing calves as the beef cross were more expensive. Differences between the systems were driven by higher feed consumption and associated costs, but also labour and building over the extra seven months before slaughter for older cattle. Costs were similar between the regions except for silage making, due to differences in forage yield and harvest machinery chains.

Economical results

You can see in the Figure that choice of beef semen for dairy cows is not a major factor influencing profitability – compared with access to agri-environmental and support payments or higher returns following a longer, less intensive finishing system. The figure also indicates, if agri-environmental payments and supports decrease by 20% all steer rearing systems would lose money with negative margins. However, if existing buildings without other profitable uses could be utilized, all rearing systems would yield a positive margin, or at least break even, given the agri-environmental payments and supports of today.

Using beef semen or not in dairy cows is not the big question for profitability in forage based beef systems. The most important issue is the access to agri-environmental payments and supports, where the extensive system with two grazing periods gives better profit than slaughter young steers after a more intensive rearing.

Imprint

Citing: Holmström, K. 2020. Profitability of dairy and dairy × beef breed steers in beef production based on forage and semi-natural pastures. SusCatt technical note. Download at https://bit.ly/2GT1O-HF

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TECHNICAL NOTE

SusCatt

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Performance and carcass traits of dairy and beef × dairy bulls in forage-based beef production

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About

A high proportion of Swedish beef comes from the national dairy herd where the cows are crossed with dairy bulls. However, cross-breeding dairy cows, not needed to breed replacement heifers, with beef bulls, could improve the carcass value of the off-springs. Furthermore, finishing these cattle on forage-based diets has the potential to increased land area under perennial forages, which are important carbon sinks. This project investigated the effect of crossbreeding dairy cows with beef sires on the performance and carcass traits of their off-spring, fed different proportions of forage in their diets.

Objective

To compare weight gain, feed efficiency and carcass traits in bulls born to dairy cows crossed either to dairy or beef sires, raised indoors at two feed intensities to different ages at slaughter.

What did we do and what did we find?

Weaned calves from a commercial dairy herd started the trial at 3-3.5 months of age with a mean live weight of 119 kg. There were a total of 69 bulls from Swedish Red or Swedish Holstein cows, 35 were sired by dairy bulls and 34 were crossbreds from Angus bulls. Half the bulls from each breed were fed a high-intensity diet and slaughtered at 15 months of age whereas the other half received a lower intensity diet and slaughtered at 18 months of age. Both total mixed rations consisted of grass-clover silage and rolled barley until slaughter, supplemented with cold-pressed rapeseed cake until 200 kg live weight and rolled peas until circa 325 kg live weight. The grass-clover silage made up 36% of dry matter (DM) in the high-intensity diet and 56% of DM in the low-intensity diet.

Bulls in the project at SLU Götala Beef and Lamb Research Centre. Photo: Elisabet Nadeau

Individual feed intake and live weights were continuously registered automatically until slaughter, when carcass weights and traits were recorded followed by cutting, when cuts from one hindquarter of each animal were weighed.

Improved performance and carcass traits by cross breeding

The beef cross bulls grew, on average, 0.15 kg more per day compared to the dairy bulls (1.48 vs. 1.33 kg per day) at similar feed intakes, regardless of feed intensity. This resulted in 64 kg extra live weight for crossbred bulls at slaughter and, since killing out percent was also higher (3%), carcasses averaged 46 kg more for crossbred compared to the dairy bulls (Table), generating a greater revenue for the farmer (SusCatt Technical Note 2.2.3).

Crossbred bulls deposited more muscle and fat in their carcasses, described by higher carcass conformation and fatness scores and a lower proportion of carcass bone, compared to the dairy bulls (Table). The higher conformation

score reflects a tendency to a greater proportion of valuable retail cuts. Furthermore, the fatness score of the crossbred bulls reflects in a higher degree of visually assessed intramuscular marbling in sirloin steaks and more fat trim in the carcasses.

Carcass for scoring of conformation and fatness. Photo: Karin Wallin

Lower effect of feed intensity

The daily liveweight gain for bulls fed at the high intensity and slaughtered at 15 months averaged 0.14 kg more than for bulls on the lower intensity diet and had better feed efficiency, regardless of breed.
However, bulls fed at the lower rate, slaughtered at 18 months reached higher live weight, produced a heavier carcass (+ 41 kg), and had a tendency for higher carcass fatness score, reflected in a greater marbling score of the sirloin steak (Table).

Foreman Jonas Dahl with one of the bull calves. Photo: Elisabet Nadeau

Conclusion

Using Angus semen on dairy cows gives bull calves with a potential for higher weight gains, carcass weights and better carcass characteristics regardless of feed intensity and the proportion of forage in the diet.

Table. Carcass characteristics of purebred dairy (D) and cross-bred dairy x beef (C) bulls fed at high (H) or low (L) feed intensity.

	Breed		Intensity		*P* - value[a]	
	D	C	H	L	Breed	Intensity
Live weight, kg	654	718	650	722	0.002	< 0.001
Carcass weight, kg	343	389	346	387	0.001	0.002
Dressing, %	52.5	54.2	53.1	53.5	0.003	0.363
Conformation[b]	5.5	7.3	6.3	6.5	< 0.001	0.499
Fatness[c]	8.1	9.6	8.6	9.1	< 0.001	0.064
Marbling[d]	1.5	2.3	1.7	2.1	< 0.001	0.005

[a]*P* – values < 0.05 indicate significant differences between breeds and between feed intensities. [b]EUROP system: 5 = O, 6 = O+, 7 = R-. [c]EUROP system: 8 = 3, 9 = 3+, 10 = 4-. [d]Visually determined in sirloin steak on a scale 1 = lean and 5 = well-marbled.

Imprint

Citing: Nadeau, E., 2020. Performance and carcass traits of dairy and beef × dairy bulls in forage-based beef production. SusCatt technical note 2.2.1. Download at https://bit.ly/2GT1OHF

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Eating quality of meat from dairy and beef × dairy bulls in forage-based production

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About

A high proportion (60-65 percent) of Swedish beef comes from our dairy herds. Although most cows are bred with dairy semen to supply replacement heifers, crossing some cows with beef breeds increases the value of calves and subsequent carcasses but could have impact on beef eating quality. This SusCatt study investigated the effect on meat eating quality of crossbreeding dairy cows with beef sires, for cattle fed different proportions of forage.

Measurement of ultimate $pH_{24hours}$ in meat from the loin muscle (M. longissimus dorsi). Photo: Karin Wallin

Objective

Another part of the SusCatt study identified crossbred dairy calves to have higher growth potential compared to purebred dairy calves - but does this influence beef eating quality? Therefore, in this part of the study we compared quality attributes of meat from crossbred and pure bred dairy bulls fed with two proportions of forage in their diets.

What did we do?

The study compared meat quality from 34 dairy x beef bulls (Swedish Holstein x Angus and Swedish Red x Angus) with 35 dairy-bred bulls (Swedish Holstein and Swedish Red), all raised indoors to slaughter. Half of the bulls from each breed group were fed a high-intensity diet (36% silage of diet dry matter (DM) for slaughter at 15 months. The others were fed a lower intensity diet (56% silage of diet DM) and slaughtered at 18 months. The total mixed rations consisted of grass-clover silage and rolled barley grain, with rolled pea and cold-pressed rapeseed cake initially, to meet higher protein needs of young calves. More details on rearing, performance and carcass quality are in SusCatt technical note 2.2.1; https://bit.ly/2GT1OHF

Post slaughter, chilled carcasses (aged for 7 days) were sampled from the strip loin muscles (M. longissimus dorsi) and frozen prior to assessing classical technological meat quality including;

- $pH_{24hours}$,
- tenderness as Warner-Bratzler shear force,
- colour - values for lightness, redness and yellowness
- water holding capacity from thawing and cooking losses.

Since all these aspects of eating quality are influenced by post-mortem changes in the muscles, dictated by the pH, this alone gives a good indication of ultimate eating quality in fresh meat. Furthermore, sensory attributes were assessed by a trained expert panel and fatty acid composition was analysed.

Similarity in meat quality between breeds

In almost all respect, meat quality did not differ between the groups. With respect to tenderness, the most important meat quality trait, no difference existed between breed types. Angus crosses had greater thawing losses, but cooking or total losses were the same, which reflected in similar results for moistness and tenderness between the breeds. The only differences identified were in colour; meat from Angus crosses had a higher lightness (L*), redness (a*) and yellowness (b*) compared to meat from pure dairy bulls. Greater lightness is most likely due to the higher degree of fat marbling. Meat redness, (red component of the total colour) explains the relative proportion of red and white muscle fibre type composition and hence the concentration of the meat pigment myoglobin and its chemical state. However, at this stage, these differences cannot be explained as an eventual muscle difference between these breed types.

Meat marbling was influenced by both breed and feed intensity

Low feed intensity, as well as Angus genetics, both gave higher degree of marbling fat in the meat, compared with the high feed intensity and dairy breed, which is positive for meat quality.

Feed intensity influenced thawing losses and sensory quality

Meat form bulls fed at the high feed intensity had greater thawing losses and the sensory test showed higher values for 'visible tendon-fat' and mouth moist sensation but lower values for 'stable smell'.

Neither breed nor feed intensity influenced the fat composition

Fatty acid profiles were the same for meat irrespective of breed or finishing system.

Conclusion

Using Angus semen (rather than dairy sires) for dairy cows and the choice of feeding intensity for the resulting bull calves have only minor influences on meat quality. Angus genetics led to higher lightness and redness colour components, regardless of feed intensity and all meat, regardless of breed or feeding system, was tender.

Beef with fat marbling, which adds flavor and is therefore an important criteria for eating quality of meat; the more marbling it contains, the better is the eating quality. Photo: Karin Wallin

Imprint

Citing: Karlsson, A.H., 2020. Eating quality of meat from dairy and beef × dairy bulls in forage-based beef production. SusCatt technical note 2.2.2. Download at https://bit.ly/2GT1OHF

SusCatt was possible by funding from SusAn, an ERA-Net, co-funded under European Union's Horizon 2020 research and innovation programme (https://www.era-susan.eu/), Grant n°696231. Other financiers were The Swedish Research Council Formas, Västra Götalands Regionen Grants n°RUN-2018-00137-8, Interreg ÖKS Grant n°20200994, Agroväst and Nötkreatursstiftelsen Skaraborg.

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SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Profitability of dairy and beef × dairy bulls in forage-based beef production

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About

Can dairy bred bulls be economically sustainable? We compared the economics of pure-bred and beef-cross bulls under two forage systems, in three Swedish regions covering a range of conditions for forage and grain production.

Objective

The income from beef production is a combination of slaughter income, other payments and supports. This study investigated if cross-bred bulls offer greater profitability compared to pure-bred dairy calves under two forage-based systems, accessing higher or lower payments and supports.

What did we do?

The study was based on a trial reported in SusCatt Technical Note 2.2.1. Bulls of two breed combinations (dairy vs. beef x dairy) were compared in two forage feeding systems. The dairy breeds were Swedish Red and Swedish Holstein and beef breed used was Angus. The systems included moderately high indoor feed intensity reaching slaughter conditions at 15 months of age, and the other system involved lower indoor feed intensity and slaughter at 18 months of age. An enterprise budgeting technique used performance from the original all-in-all-out trials to assess profitability of continuous rearing, assuming calves were born throughout the year. Profitability was assessed for three different geographical Swedish regions;

1. plain district (PD) of southern Sweden, no less-favoured area (LFA) support, with facilities for chopped silage and home-grown grain.
2. forest district (FD) of southern Sweden, situated in an LFA, with round-bale silage making, and purchased grain.
3. northern Sweden (ND), within LFA, with facilities for chopped silage and home-grown grain.

The bulls in the experimental facilities at SLU Götala Beef and Lamb Research Centre, Skara. Photo: Elisabet Nadeau

In addition to basic calculations, sensitivity analyses were conducted to allow i) using existing building without a profitable alternative use and ii) if payments and supports were 20% lower than present.

Higher income from older bulls

The enterprise budgeting calculations (in the figure) showed that breed choice influenced incomes more than the production system, where beef crosses gave a better profitability. Older, heavier bulls gave higher revenue compared to faster finished, younger and lighter bulls. In comparison to steers, bulls have a higher income from carcasses but lower payments and supports.

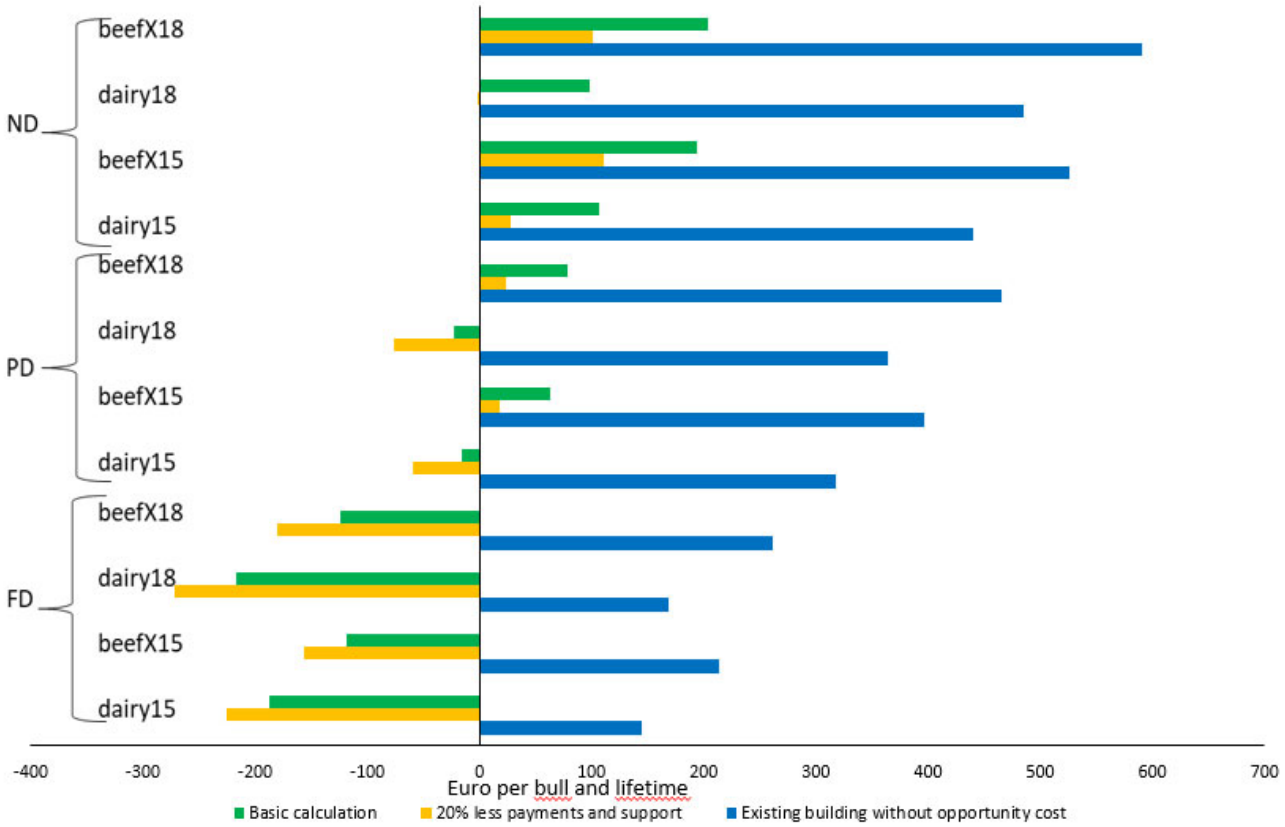

Figure. Basic calculations and sensitivity analysis for profitability (Euro/bull) of purebred (dairy) and beef crossbred (beefX) bulls slaughtered at 15 months (15) or 18 months(18) of age, in forest (FD)), plain (PD) and northern (ND) districts of Sweden.

Small differences in costs

The largest costs were for buildings and calf purchase, followed by grain, silage making and labour, with only relatively small differences between the twelve combinations tested. However, there was a difference in cost between breeds for calf purchase, as the beef crosses were more expensive. Differences between the rearing systems were driven by higher feed consumption and associated costs, but also labour and building over the extra three months before slaughter for older cattle. Costs were similar between the regions except for silage making, due to computed differences in forage yield and harvest machinery chains, and home grown or purchased grain.

Economical results

Results suggest the choice of beef semen for dairy cows is a major factor influencing profitability in finishing male calves, together with the target age of slaughter. The figures also indicate that bulls reared on farms with their own grain and facilities for cheaper silage making have a close to zero or a positive bottom line. However, if existing buildings without alternative profitable uses could be utilized, all rearing systems would yield a positive margin, given the current payments and supports of today.

If replacement heifers are not required, using beef rather than dairy semen for dairy cows is a good choice for profitability with facilities for indoor, forage-based systems. Other relevant issues are access to low cost feeds and buildings, where more extensive finishing at 18 months gave better profit than slaughtering young bulls after semi-intensive rearing.

Imprint

Citing: Holmström, K., 2020. Profitability of dairy and beef × dairy bulls in forage-based beef production. SusCatt technical note 2.2.3. Download at https://bit.ly/2GT1OHF

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Sustainability factors of the Italian beef rearing system

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About

We investigated if greater use of home-grown forages and by-product feeds for intensive beef can maintain good production and economic performances, ensure animal health and welfare as well as reduce the farms' environmental impact.

Challenge

Beef production is blamed to be environmentally unsustainable because a) much of their diets can be eaten directly by humans and b) for its gas emissions into the atmosphere. If the industry is to improve sustainability, farms need to know what conditions will allow them to reduce their harmful impact without reducing profitability or assess whether subsidies are justified for adopting good farming practices.

The Italian context

Livestock farming, particularly those confined to housing with no grazing area, has been the target of environmental and ethical accusations for years. Although this sector, especially in the Po Valley, has crucial importance, more than 40% of the meat consumed in Italy comes from other countries – is this importation sustainable? In fact, the national beef herd has remained stable over recent years. However, according to a report by Veneto Agricoltura on the Veneto region, the biggest Italian beef producer, from 2007 to 2017, the number of beef farms and of beef cattle dropped by 37.5% and 11.9%, respectively. Meanwhile, the average beef herd size increased from 48 to 68 units. This suggests that recently the Common Agricultural Policy has not increased the beef cattle population but is encouraging the remaining farmers to work more effectively, adopting good practices.

Limousine beef cattle reared on a SusCatt farm. Photo: Dr. Giorgia Riuzzi.

Some data shows intensive farms have been reducing their environmental impact, when managed carefully. In terms of emissions per kilogram of animal protein produced, methane has decreased by more than half since the mid-sixties, thanks to increasing efficiency within the national farming system as a whole. The same considerations can be made for other negative impacts such as acidification and eutrophication.

What we want to demonstrate

The assessment of the beef rearing system should be based on several linked aspects including:

- mitigating effect of crop cultivation to produce feeds;
- reducing chemical fertilizers and recycling nutrients from manures;
- feeding appropriate industrial by-products and home-grown feeds, especially forages.

On this last topic, the diets on 792 farms were evaluated to identify what was being fed. On average, by-product feeds and non-maize forages each provide 20% of the diet dry matter. The main by-products were beet pulp, molasses, distillers' grain and bran, coming from the production of sugar, alcoholic beverages and the milling industry. The Po Valley is characterized by a high level of anthropization, and associated food and drink manufacture. Whilst this might reduce the land available for farming, especially grazing, it does offer an ideal opportunity and supply of by-product feeds.Therefore, changing beef rearing towards a circular economy scenario making good use of home-grown feeds and recycling other industries' wastes will improve the production chain sustainability within the agricultural and farming systems.

Results

SusCatt seeks new knowledge whose application will be helpful to improve farm environmental efficiency, animal welfare and product quality. For these reasons, they perfectly fit within the national research activities and technical assistance initiatives that have been carried out with the aim of enhancing the production chain sustainability.

SusCatt partners visiting an Italian farm involved in the project.

Parthenaise beef cattle reared on a SusCatt farm. Photo: Dr. Giorgia Riuzzi.

Imprint

Citing: Flaviana Gottardo and Giorgia Riuzzi (2020): Sustainability factors of the Italian dairy rearing system. SusCatt Technical Note 2.3.1. Download at https://bit.ly/2GT1OHF

SusCatt was possible by funding from SusAn, an ERA-Net, co-funded under European Union's Horizon 2020 research and innovation programme (www.era-susan.eu) Grant n°696231 and Ministero delle politiche agricole alimentari e forestali (MIPAAF).

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Maize silage for beef cattle: good or bad? Health traits of dual-purpose crossbreeds and pure beef cattle

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About

Most meat produced in Italy comes from specialised intensive fattening farms in the Po' Valley, importing young beef bulls and heifers from other EU countries. Cattle are fed high proportion of concentrates and diet are dominated by maize as silage, grain, mash and in other forms. Here we discuss the impact such diets have on the animal health of two beef breeds.

Challenge

Beef production in the Po' Valley has been growing in recent decades thanks to the large-scale exploitation of maize, greater availability of imported European calves and an increasing market for beef in the Italian regions, where demand is not met by local production.

However, new and increasing challenges force farmers to find alternative strategies to keep traditional agriculture alive; Italian beef consumption is falling while the demand for imported low-price meat is increasing. On the other hand, some meat consumers are prepared to pay more but are concerned about the environmental and ethical sustainability of the products they buy. Besides, historic European measures in favour of specialist beef farms have changed leaving farmers coming to terms with detrimental financial losses. As well as all this, agriculture needs to cope with climate change, which is especially challenging for maize production.

Objective

Animal feeding is one of the main concerns and the sector is searching for innovative strategies to maintain profitability from environmentally sound and ethical systems. We investigated if replacing maize silage with other forages enhances the animal health of contrasting beef breeds.

Crossbreed beef cattle reared on a SusCatt farm.
Photo: Dr. Riuzzi Giorgia.

What did we do?

Ten beef farms in the Veneto region were involved, finishing cattle classed as either French meat breeds (FMB) or dual-purpose crossbreds (CSB). To evaluate the impact of the diets on animals' health, two farm groups were created based on the proportion of maize silage in the diets: high maize silage (HMS; ≥28% of diet dry matter) and no maize silage (NMS).

Farms were visited 4 times in 12 months to assess animal health according to the Welfare Quality Assessment Protocol for cattle (2009), recording the incidence of: lean or fat animals (based on Body Condition Score, BCS), lameness, coughs, nasal or ocular discharge, hampered respiration, diarrhoea and bloated rumens. Subsequently, records were analysed to see how breed and diet, both individually and coupled, affected the animals' health status.

Results

In our study, cattle breed has strongest effect on the health status, with specialised beef animals more affected by lameness, nasal and ocular discharge, hampered respiration, diarrhoea.

Diet proved to be relevant mainly for the specialised beef cattle for whom hampered respiration and diarrhoea were higher in cattle without maize silage whereas bloated rumen was more common on farms feeding maize silage. For crossbreed animals the differences between the diet groups was a higher incidence of diarrhoea and bloated rumen found in cattle fed maize silage.

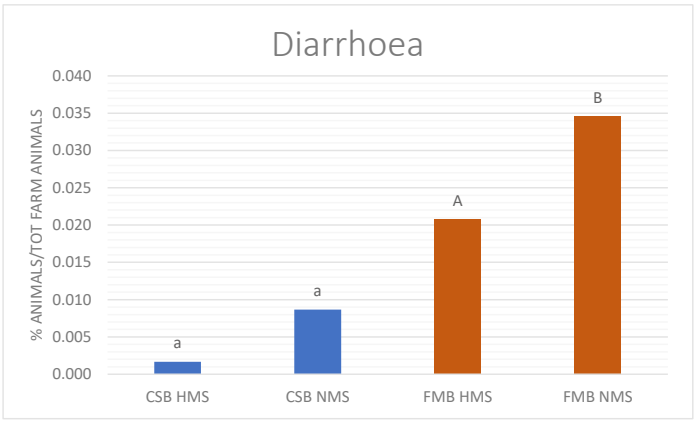
Findings on body condition deserve separate considerations. Within both breeds, diet did not have any impact on the presence of low BCS animals. However, within the specialized beef breed, HMS farms had higher number of animals with high BCS than the NMS farms.

Conclusions

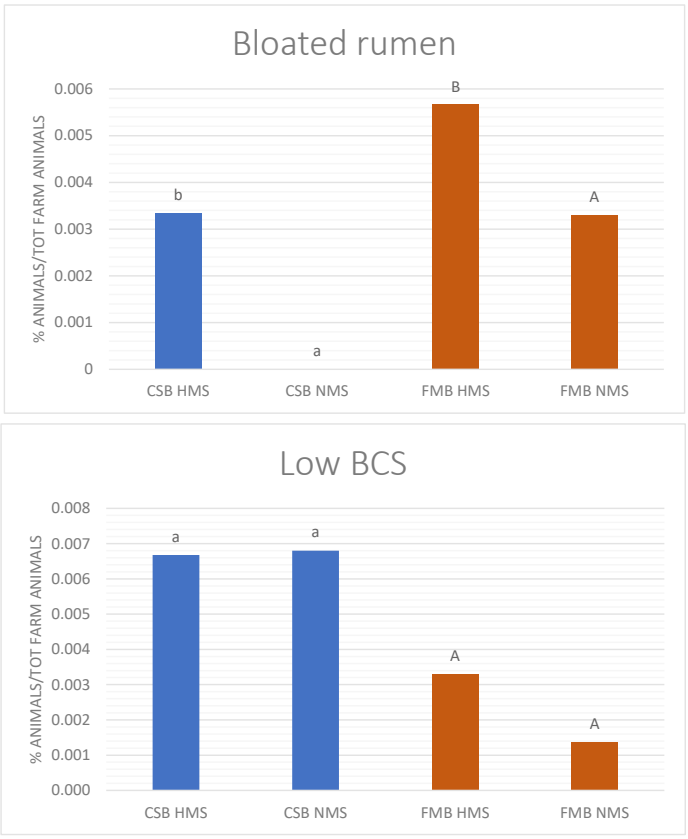
We need to develop new and alternative feeding strategies to cope with changing climatic conditions and reduced water availability, which makes maize production more difficult.

Our investigation found that feeding forages other than maize silage to purebred beef cattle does not seem to increase the percentage of thin animals (something farmers are usually concerned about) and, instead, appears to reduce bloated rumens. The negative impact of the no-maize diet on hampered respiration and diarrhoea is likely due to a dustier feed ration and faster passage of feed through the rumen, respectively.

Furthermore, dual purpose crossbreeds are valuable alternatives to specialised imported breeds showing greater resistance and adaptability to different housing, feeding and management conditions, all crucial for foreseeable changes expected in our production system. Regardless the feeding system applied, rearing Italian crossbreeds would avoid welfare issues, such as long-distance transportation.



Percentage of animals with diarrhoea on the farms rearing either crossbreeds (CBS) or pure meat breeds (FMB) fed high-maize (HMS) or no-maize (NMS) diets. The letters show difference within category, when present.



Percentage of animals with bloated rumen or low BCS on the farms rearing either crossbreeds (CBS) or pure meat breeds (FMB) fed high-maize (HMS) or no maize (NMS) diets. The letters show difference within category, when present.

Imprint

Citing: Giorgia Riuzzi, Severino Segato, Barbara Contiero, Flaviana Gottardo (2020): Maize silage for beef cattle: good or bad? Health traits of dual-purpose crossbreeds and pure beef cattle. SusCatt Technical Note 2.3.2. Download at https://bit.ly/2GT1OHF

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Better nutritional quality in grass-fed milk and meat

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Challenge

Many in societies around the world fail to achieve sufficient intakes of long-chain omega-3 fatty acids (or n-3), potentially one cause of chronic physical and mental health conditions – hence dietary advice to eat oily fish. However, meat and dairy from cattle and sheep are major sources, in the absence of high-fish intakes – highly relevant since more of us eat dairy products and red meat than fish.

Cows at grass. Photo: Hannah Davis

We can synthesise long-chain n-3 but the necessary metabolic pathway is thought to be swamped by excess omega-6 fatty acids (n-6) from our diets. So, if we are to enhance overall n-3 metabolism, it would be sensible to reduce n-6 intake, as well as eating more preformed long chain n-3. This poses the question: can we increase the long chain n-3 in milk and meat and reduce their n-6 content?

Aim

The nutritional quality of milk and beef depends on how we manage our cattle, what they eat has a direct impact on the nutritional composition of what we eat. By comparing organic and non-organic produce, we know feeding cereals or cereal by-products (concentrate feeds) to cattle diminishes n-3 and increases n-6 in milk and meat. In SusCatt, this comparison was taken to the next level - to evaluate the potential to improve nutritional quality further, by considering products from very extensive, grazing-based farming.

What did we do?

Several studies in SusCatt monitored the balance of fatty acids in different types of milk and beef, including from low-input systems where cattle eat nothing but forage (as nature intended for ruminants!) – grazing in summer and fed silage or hay in winter, when cold, wet conditions reduce plant growth.

Milk composition was considered across 5 different systems. Non-organic and organic (blue-top) milk was sourced from 5 different supermarkets on 3 occasions between April and October. The farm sourced milk came from 69 individual cows on 3 low-input farms feeding either a) 100% forage with no concentrates, b) 90% forage and 10% concentrates or c) 85% forage and 15% concentrates in the cows' diet - again collected 3 times between March and October. To put this into context, many non-organic farms might typically feed 30-50% concentrates and organic farms slightly less (certainly less than 40%).

The beef study considered non-organic and organic sirloin steak from 2 supermarkets, this time comparing them with meat from 2 certified 100% pasture-fed farms. We took the opportunity to also include meat from cattle primarily kept for vegetation management to enhance biodiversity. Strictly speaking these conservation steaks were not directly comparable with the others in the study since they were sourced at different times in the year (which we know influences composition) however it was a novel opportunity to investigate meat from these unusual systems.

What did we find?

Reporting fatty acid profiles can get confusing due to the vast number of fairly specialised results generated. Full results from these studies have been published (Davis et al. 2020a, Davis et al. 2020b, Butler et al 2021) and here we present only those likely to influence the long-chain omega-3 supply:

- sum of long-chain n-3 (EPA+DPA+DHA)
- ∝-Linolenic acid (ALA, C18:3, n-3) the precursor for long chain n-3 synthesis
- Linoleic acid (LA, C18:2) the main n-6 thought to block n-3 metabolism
- ratio of linoleic acid to ∝-linolenic acid (LA:ALA) thought to control n-3 metabolism

The 2 charts present concentrations of these fatty acids and their ratios in milk and beef from the various farming systems. They confirm the concept that feeding concentrate feeds to dairy cows or beef cattle is detrimental for the long-chain n-3 in their products – either the direct supply and/or the scope for synthesis, by increasing n-6 or LA content.

Milk is not particularly rich in n-3, although higher from 100% forage diets. However, the most striking difference between systems is the LA (n-6) content relative to ALA (n-3), with an incremental decline going from non-organic, organic, and diminishing levels of concentrate feeding. A switch from mainstream to dairy products from cows fed solely forage diets would reduce this ratio from nearly 4 :1 (4 parts 0f LA to every 1 of ALA) down to less than 1:1 - supplying more ALA than LA, which will help the overall dietary balance and potential to convert ALA to long-chain n-3.

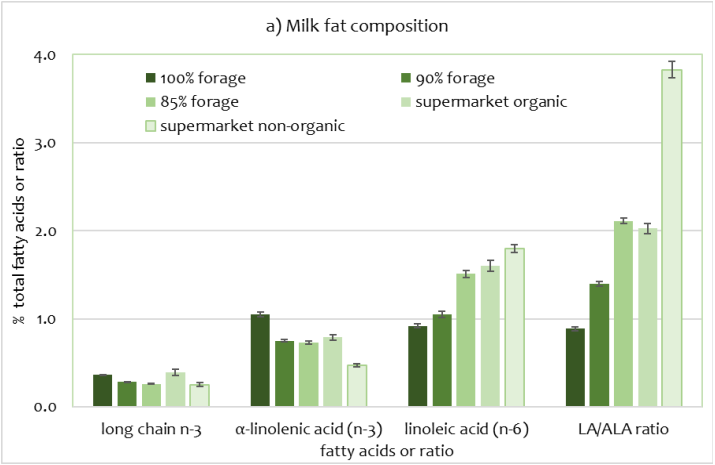

Figure a. Mean concentration of fatty acids in milk (± standard error of means) from 5 production systems

We see a different picture with beef; it is considerably higher in long-chain n-3 and ALA than milk, although the ratio with LA is also higher (ie poorer). All show clear differences between the farming systems – favouring meat from the extensive conservation and pasture production. System differences are less clear cut for LA content but the ratios relative to ALA range from around 2:1 for the beef from conservation and pastured cattle up to 7:1 for the non-organic beef. One really exciting result here identifies meat from extensive forage-based systems could legally be considered as a 'source of long chain omega-3 fatty acid' (unlike supermarket sourced steaks) (see: https://ec.europa.eu/food/safety/labelling_nutrition/claims/nutrition_claims_en) and the relative concentration of LA and ALA is likely to enhance further metabolic synthesis.

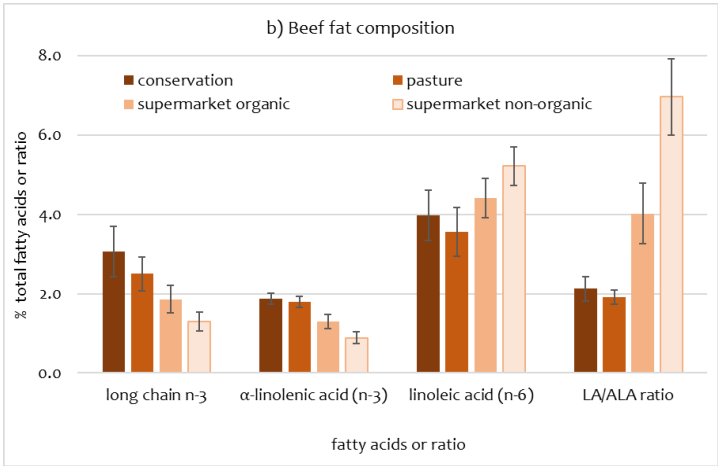

Figure b. Mean concentration of fatty acids in muscle tissue (± standard error of means) in sirloin steaks from 4 production systems

Conclusions

These results from SusCatt add to the evidence on the superior nutritional quality of products from extensive farming, highlighting the potential benefits from forage only feeding. In addition, they show the scope for certified pasture-fed beef to lessen consumer deficiencies in long chain omega-3 fatty acids consumption.

Imprint

Citing: Davis, H., Butler G. and Magistrali, A. (2020): Better nutriti-onal quality in milk and meat. SusCatt technical note 2.4.1 / 3.1.2. Download at https://bit.ly/2GT1OHF

References: Davis, H., E. Chatzidimitriou, C. Leifert and G. Butler (2020)a. "Evidence that forage-fed cows can enhance milk quality." Sustainability (Switzerland) 12(9).
Davis, H., S. Stergiadis, E. Chatzidimitriou, R. Sanderson, C. Leifert and G. Butler (2020)b. "Meeting Breeding Potential in Organic and Low-Input Dairy Farming." Frontiers in Veterinary Science 7.
Butler G., Mohamed Ali A.,Oladokun S., Wang J., David H. (2021) Forage - fed cattle point the way forward for beef? Future Foods 3 100012

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Nutritional quality of pasture-fed beef

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Background

Many try to eat sustainably yet the necessary information may be lacking and often the environmental impact of food production dominates their consideration. The nutritional quality of the food we produce is also relevant and depends how we manage our farms - what our animals eat has a direct impact on the composition of their meat. This note focuses only on one aspect of beef's nutritional quality, although the Pasture Fed Livestock Association highlights other sustainability benefits offered by pasture-feeding, including: farm returns, animal welfare and environmental impact. In addition, SusCatt Technical Note 4.4.1 discusses consumer attitude to grass-fed.

A major weakness of many modern diets around the world is a shortage of long-chain omega-3 fatty acids (or n-3, including EPA, DPA and DHA), potentially one cause of numerous chronic physical and mental health conditions – hence the advice to eat oily fish. However lean red meat could be a reliable, alternative source, especially for those who rarely eat fish.

In theory, we can synthesise these deficient long-chain omega-3 fatty acids but the necessary metabolic pathway is thought to be swamped by excess omega-6 fatty acids (n-6) from our diets. So, if we are to enhance overall n-3 metabolism for consumers, the challenge is to reduce n-6, as well as increasing long chain n-3 in the meat we produce.

Aim

By comparing meat composition from different production systems, we know feeding cereals or cereal by-products to cattle diminishes n-3 and increases n-6 in meat but there is little evidence from cattle fed only forage throughout their life. In SusCatt we considered fat composition, looking at beneficial fatty acid profiles in steaks from 4 UK systems: non-organic, organic, certified pasture-fed and conservation cattle.

Sirloin steak. Photo: G. Butler

What did we do?

Non-organic and organic sirloin steaks were bought from 2 supermarkets during May and June 2019 and this was compared with steaks from cattle on 2 certified 100% pasture-fed farms, slaughtered over this time span. We also took the opportunity to include meat from cattle kept primarily for vegetation management to enhance biodiversity. Strictly speaking these conservation steaks were not directly comparable with the others in the study however it was a novel opportunity to investigate meat from these unusual systems. Some came from cattle slaughtered at different times in the year (which we know influences composition). Before analysis, all steaks were separated into subcutaneous fat (which has the option t0 be avoided by consumers) and muscle tissue, including marbling fat.

What did we find?

Reporting fatty acid profiles can get confusing due to the vast number of fairly specialised results generated. Full results have been

published (Butler et al 2021) but here we focus the most exciting aspect of our results - differences likely to influence the long-chain omega-3 supply from the steaks:

- sum of long-chain n-3 (EPA+DPA+DHA)
- α-Linolenic acid (ALA, C18:3, n-3) the precursor for long chain n-3 synthesis
- Linoleic acid (LA, C18:2) the main n-6 thought to block n-3 metabolism
- Relative concentrations of linoleic acid to α-linolenic acid (LA:ALA ratio), thought to control n-3 metabolism

The chart presents concentrations of these fatty acids and their ratios found in the muscle tissue from the 4 farming systems, with clear differences. Results confirm the concept that feeding concentrate feeds is detrimental to the potential for long-chain n-3 supply from meat - assuming non-organic beef production for supermarkets is more intensive than organic, which in turn is more intensive than pasture-fed (100% lifetime forage diets). This applies both in terms of the direct supply of n-3 but also the scope for metabolic synthesis by consumers, since it increases n-6 or LA content.

The concentrations of all n-3 are higher in steaks from extensive conservation and pasture production. System differences are less clear cut for LA content but the ratios relative to ALA range from around 2:1 for the beef from conservation and pastured cattle up to 7:1 for the non-organic beef. Results show meat from both these extensive forage-based systems in this study can legally claim to be 'a source of long chain omega-3 fatty acid' (unlike any of the steak sourced from the supermarkets) (as per: https://ec.europa.eu/food/safety/labelling_nutrition/claims/nutrition_claims_en). In addition, the bonus of a low ratio of LA to ALA is likely to enhance synthesis of more long chain omega-3 by consumers.

Steaks in this study were bought in early summer, probably from cattle finished on winter diets. We know, for many cattle, seasonal differences in feeding influences fat composition so the plan was to repeat the study in autumn, to judge the impact of summer diets. These steaks were bought, analysis started but then unfortunately Covid restrictions interveaned so we need to be patient and wait for these follow-up findings.

Conclusions

These results from SusCatt add to the evidence on the superior nutritional quality of meat from extensive farming, highlighting the benefits of forage only feeding. In addition, they show the scope for certified pasture-fed beef to avert consumer deficiencies in long chain omega-3 fatty acids intake.

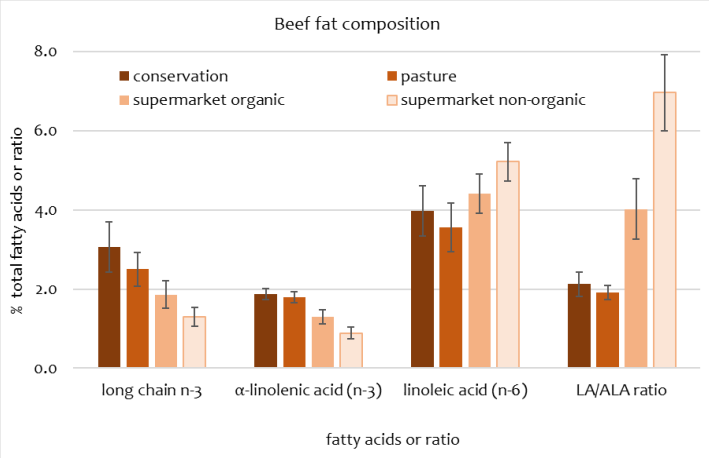

Chart: Mean concentration of fatty acids in muscle tissue (±standard error of means) in sirloin steaks from 4 production systems

Beef cattle at grass. Photo: Gillian Butler

Imprint

Citing: Butler G. (2020): Nutritional quality of pasture-fed beef 2.4.2. Download at https://bit.ly/2GT1OHF

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Which cows suit UK low-input or organic dairying?

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Challenge

For years, breeding in mainstream dairying focused on increasing milk yield, but these high-performance cows do not suit low-input production. UK interest in grazing based dairying has risen over the last 20 years, yet there is little guidance on breeding priorities, with individual farms customizing crossbreeding to suit their system. Here we describe lessons learned from 17 such farms.

Typical crossbred cows. Photo by Acorn Dairy, Darlington, UK.

Objective

In the absence of a coordinated approach to dairy breeding for low-input systems, each farm has largely been left to their own devices. Ideally, they want cows to maintain a reasonable yield of quality milk but they must get cows back in-calf, avoid mastitis and other ailments. Most farms use a combination of breeds and crosses, so inevitably it takes several generations to reach a conclusion (if it ever does?). This has been repeated up and down the country so, here we aim to coordinate information from innovative farms, looking for common themes which might short cut the process for future practitioners. Another interest was to investigate the scope to enhance milk fat composition – aiming to breed cows that produce milk with more good omega-3 fats, which we lack in our diet.

What did we do and what did we find?

Seventeen herds were involved (7 organic and 10 low-input-conventional); all a mix of both purebred and crossbred cows, with the pedigree of each cow described by the farmers. Production, fertility and health records from just over 1000 cows were collected 4 times over a year. We also took individual milk samples each time, assessing fatty acid profiles, as well as basic composition including fat, protein and somatic cell counts.

In total we collected information on 40 different breeds and crosses; some in small numbers and maybe only on single farms. However, to generate guidance relevant for a range of systems, we restricted the comparison to records with at least six cows of the same breed (or combination), on at least three different farms – bringing the number of breeds down to 8 (listed in the table).

All individual assessments were then combined to give 2 overarching scores, for every cow recorded under these 8 breeds. These scores had different weightings to allow breed ranking under 2 differing priorities:

1. Health score: 30% production, **50% health** and 20% fatty acids.
2. Production score: **60% production**, 30% health and 10% fatty acids

Results 1

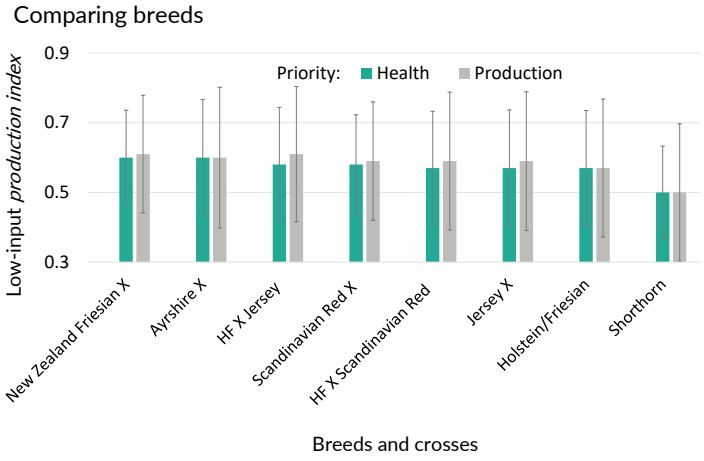
We set off to rank the suitability of the breeds and crosses for low input dairying. However, we found the greatest impact on the records collected was not 'which cow' but 'which farm' - how they were managed, a good system is good, irrespective of breed.

Maybe we should not be surprised that no single breed or combination was outstanding in every characteristic – all appeared to have strengths and weaknesses (relative to other breeds in the study):

Breed or cross	No.	Strength	Weakness
Ayrshire X	100	Fat composition	Antibiotic treatments
Holstein/ Friesian	325	Milk yield	Fat composition and antibiotic treatment
Jersey X HF	184	Milk and solids yield	Fat composition and antibiotic treatment
Scandinavian Red X HF	274	Milk and solids yield	Fat composition
Jersey cross	121	Antibiotic treatment and fat composition	Milk yield
NZ FriesianX	90	Udder health and antibiotic treatment	Mid-range for milk yield
Dairy Shorthorn	80	Antibiotic treatment, mid-range for fat quality	Milk and solids yield
Scandinavian Red X	140	Udder health	Mid-range for solids yield

Results 2

Surprise, surprise – strengths and weaknesses balance out, so combining records to give the overall scores actually shows very little between the breeds and considerable variation within them – a consequence of the different farming system involved.



Based on these records, the chart [bottom left] shows crosses with New Zealand Friesian genetics fair best under systems with either production and health priorities. As for the other breeds, farms where animal health is important might also consider Ayrshire crosses although they have a lower production potential. Shorthorn or Jersey crosses would not be a good idea if herd health is critical. On the other hand, if the farm system prioritises milk and solids yield, any crosses with Holstein/Friesian ought to fair OK although Jersey crosses might be more vulnerable to health challenges, compared with the Scandinavian crosses.

Conclusion

Records collected from 17 low-input and organic dairy farms show breeding strategy is less critical than other aspects of management. All breeds and crosses monitored show a wide range in performance, with differing strengths and weaknesses. Cows involving New Zealand Friesian genetics fair best overall with respect to production, animal health and fat composition whereas Shorthorns were at the other end of the scale.

Farmers need cows to suit their system although breed choice is only one decision leading to a sustainable enterprise.

Imprint

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Selecting for Efficiency in Pasture-Based Dairying

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Challenge

Pasture-based dairying relies on effective conversion of grazed herbage into milk while cows maintain body condition, health and fertility. These systems have very different priorities compared with typical intensive, yield driven dairy production. How do farmers identify the best cows (and bulls) to breed herd replacement from, when most published selection criteria focus on more intensive systems – even those suggested for spring calving herds?

Objective

This study investigated the scope to improve forage-conversion efficiency by considering variation between individual cows in pasture-based herds. By closely monitoring cows on three UK pasture-based dairy systems, we considered how farmers could select for positive traits within these sustainable production systems.

Farm and Cow Selection

Three organic dairy farms in the Southern Midlands joined the study, based on the following:

1. Spring-calving
2. Pasture-based (at least 85% forage in diet)
3. 30 or more second and/or third lactation cows

Each farmer randomly selected 23 second/third lactation cows, aiming for a range of ages, breeds, size and productivity.

RumiWatch Halters

Selected cows were fitted with RumiWatch halters (Itin+HOCH, Switzerland) - to record grazing and ruminating behaviour and estimate dry-matter intake (DMI). These halters have high-tech, pressure-based recording systems, validated to log real-time eating, ruminating and drinking activity in-field over days and weeks. The cows at each farm wore the halters for two weeks at three key times in 2018, covering early (E; <100 days in milk / DIM), mid (M; >101 and <200 DIM) and late (L; >201 DIM) lactation.

Dairy cow wearing a RumiWatch halter, Photo: Gillian Butler

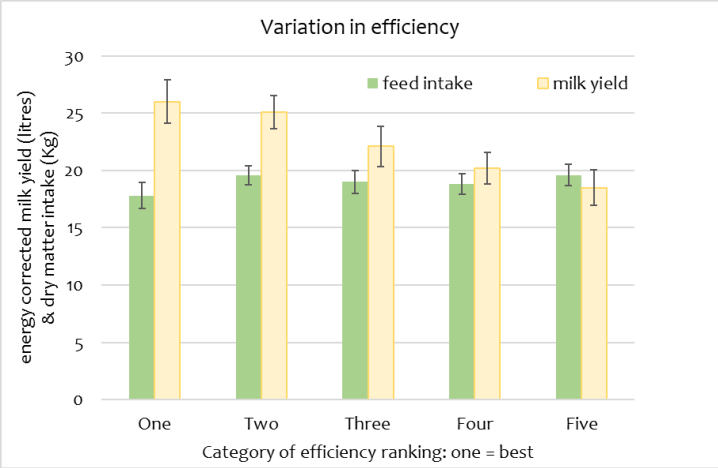
During each period of data logging, we also recorded milk yield and composition (protein and fat content). These were used to standard- ize output as 'energy corrected milk yield' (or ECMY, based on 3.5% fat and 3.2% protein) to allow fair comparison between cows producing milk of different composition.

Variation in cow performance

While comparing records from the different farms provides insight into the impact of subtle differences in management, the main

aim of this study was to gain a greater understanding about feed conversion, gleaned from looking at variation in production efficiency between individual cows under similar management.

Records from all 3 farms were used to calculate production efficiency for all monitored cow, based on estimated dry matter intake (kg) for each litre of EC milk they produced. Cows were ranked and considered in 5 groups (each with 27-31 records); the most efficient with the lowest score as Group One, declining to the least efficient as Group Five. Grouping the cows by efficiency allows us to consider other factors that might be linked to their efficiency category.



Mean feed dry matter intakes (green) and energy corrected milk yield (yellow) (±sem) for groups of cows ranked according to production efficiency.

The chart shows average feed consumption (green bars) and adjusted milk yields (yellow bars) for the 5 efficiency groups. Since the standard calculation for ECMY is based on a relatively low-fat content, the adjusted yield for cows producing high butter fat milk are boosted disproportionately, so it is perhaps not surprising that milk fat content was greatest for Group One cows and lowest for Group Five.

The key message from this study is the extent of variation existing even under comparable management, indicating the potential to breed more efficient cows – bearing in mind other necessary traits for pasture-based dairying. Comparing the 2 extremes: the least efficient cows (in Group Five) ate 9% more yet produced 40% less EC milk than cows in Group One, working out at 1.14 kg of grazing plus supplement for every litre of milk produced, compared with only 0.72 kg for the most efficient cows in Group One. However, it is particularly relevant to note that production efficiency did not always follow milk yield, so selecting solely on milk, or solids, yield will not necessarily breed from the most efficient cows.

Ideally, we ought to identify superior cows in early lactation before they are inseminated, so it would be useful if early production efficiency is a reliable indication of overall 'breeding value'. Unfortunately, due to missing records, those collected here for early lactation did not reliably indicate the best overall cows. On the other hand, we did see consistency for cows at the other end of the scale – there appears to be scope to use early lactation records to identify cows to avoid for breeding replacement heifers.

Although the nuances of eating behaviour were measured by the RumiWatch halters, their links to production efficiency are difficult to distill. Cows in Group One had the lowest intakes - they appeared to spend less time eating and ruminating with the fewest 'chews per bolus' – yet still produced the most milk. This indicates we need a better understanding of how eating behaviour impacts an individual cow's abilities to convert forage to milk.

Conclusion

The study showed certain individual cows on pasture-based farms are consistently more efficient than average through lactation and could be selected for breeding replacements to maintain and improve grazing conversion efficiency within the system. While this is true, the participant farmers (and many others) have already adapted genotypes best suited to their systems and are ahead of the research in many ways. While the results support farmer decision-making, dairy science research needs to catch up.

Imprint

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Cross-under-sowing: improving permanent pasture without herbicides

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About

Permanent pastures support valuable animal production although this depends on how they are managed, and hence, what plants are present. Poor conditions are often caused by neglect, although they can arise from overgrazing or damage from grazing animals or machinery in wet conditions. The pastures can be renovated using specialist machinery to introduce more productive grasses. Cross-under-sowing using a direct drill fitted with a tine cultivator proved successful without the need for controversial pesticide application.

Challenge and objectives

In many European countries, permanent grassland covers between 10% and 70% of all farmed land, which, if properly managed, is an important source of feed for ruminants. On the other hand, if neglected, they become dominated by relatively unpalatable and unproductive weeds. The main goal of this work was to improve pasture yields through mechanical weed control using a tine cultivator, combined with direct drilling to introduce tetraploid grasses, white and red clover and herbs into existing meadow swards.

We aimed to improve the yield and nutritional value of permanent pasture and meadows, using a band-tilling seeder, without relying on herbicides to destroy the existing sward during renovations. Improving both grass growth and its nutritional value, will allow farms to graze more cows and/or support higher yields or growth rates from forage.

Undersowing with rotary band-tilling with tine cultivator, cutting turf with disc coulters. Photo: J. Barszczewski.

Permanent grassland renewal: methods

Effective pasture renovation, introducing valuable grasses and legumes whilst maintaining biodiversity, can be done by 1 of 3 ways, depending on the state of the existing sward and soil conditions:

1. fertilization and rational use
2. under- or over-sowing (traditionally or using specialized seed drills)
3. full cultivation and reseeding

All have pros and cons relating to practicalities, continuity of feed supply and economy.

Grassland renewal: basic conditions

Successful under- or over-sowing can be used when:

- the surface is fairly even with limited damage
- the existing sward lack many productive grasses or legumes
- plants present are unpalatable or of low digestibility

- weeds make up less than 40% of the sward
- persistent weeds forming clumps and stolons is less than 20%
- the sward has been heavily damaged during winter or from prolonged water logging

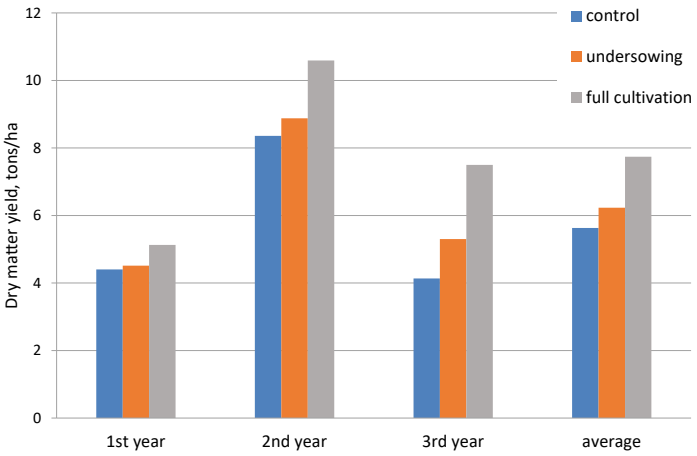
Combined Band-Rotating Tillage and Seeding

In modern under-sowing, seeds are introduced directly into the soil using two main types of special seeders:

1. rotary band-tilling aggregates and slot-cutting turf (image 1). Here disc cutter or knife destroys about 40% of the old turf and introduce seeds into soil in the notches or slots created.
2. rotational (band-tilling) method – which is more effective for high organic matter soils where plasticity might lead to insufficient slotting (disc coulters) and difficulty introducing seeds into the soil

Cross-undersowing with a rotary band-tilling seeder with tine cultivator (cutter). Photo: J. Barszczewski.

Whichever method is used, the key factor for success is adequate soil moisture, enabling rapid germination and growth of young seedlings. With moderate weed infestation on mineral soils, effective planting is possible with a single pass of the band-tilling aggregate. However, with high weed infestation, particularly poor swards or high organic matter soils, it might be necessary to use cross-under-sowing, to eliminate the need for herbicides to destroy the undesirable plants. Cross-under-sowing with the aggregate (image 2), mechanically destroys weeds, partially maintaining local ecotypes and biodiversity of the plant communities and, most importantly, replaces full cultivation limiting its mineralization and associated greenhouse gases emissions.



Grass yield after direct drilling (undersowing) or full cultivation (ploughing and reseeding) compared with no renovation (Control).

The figure above shows the yield advantages following pasture renovation, comparing full cultivation and under-sowing (method 1 above, image 1) with untouched, control swards. The yield was on average 20% higher with undersowing and 30% higher with full cultivation compared with the control. However, if the underlying causes for the original deterioration (poor drainage, overgrazing, animal or machine access in wet conditions, low pH or fertility) are not addressed, this will be transient as the new plants struggle in adverse conditions. The nutritional quality of the herbage was also improved with direct drilling, with higher protein and lower fibre concentration than in control.

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Improving milk output from permanent grassland

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Challenge

Between 10% and 70% of European grassland is permanent. Much of this land offers a dilemma - while some offers important semi-natural habitats, there are large areas where years of mismanagement has led to poor biodiversity, despite the plant populations having low productivity. Could renovating these degraded pastures by introducing more productive forages support higher dairy production?

The cows on the pasture at Biebrza farm in Poland . Photo: J. Barszczewski.

Challenge and objectives

The main goal of this study was to monitor milk yield and quality following the introduction of tetraploid grasses, legumes and herbs into permanent pastures used for grazing and silage making. Pasture renovation is described in another SusCatt Technical note 3.2.1.

What did we do?

Milk yield and cheese making quality was monitored from Holstein Friesian and Simmental dairy cows for 2 years, comparing output from renovated pasture with that from improved swards. All animal grazed in the summer and were housed and fed silage diets in winter with low levels of concentrate supplementation. Half the cows from each breed were allocated to the 'renovated' pastures and forage from the 'control' cows came from comparable areas of unimproved pasture.

What did we find?

Renovation of pastures and meadows reduced weeds in the sward from 28% to only 6-7% with the proportion of productive grasses increasing from 60% to 69-71% and legumes (mostly red and white clover) from 3% to 22-25%. The figure below shows the recorded performance for the different pasture types over summer and winter.

The sward on the renovated (left side – High share of white and red clover) and not renovated meadows (on the right side). Photo: J.Barszczewski

For winter milk from cows fed grass silage diets, the renovated pasture resulted in higher milk fat, protein (including casein) and urea compared with silage from control pastures but there was little difference in milk yield (overall average of 22.6 vs 21.9 kg/cow/day). On the other hand, in summer cows grazing the control pasture produced more milk than cows on renovated pasture (24.6 vs 21.9 kg/cow/day) although

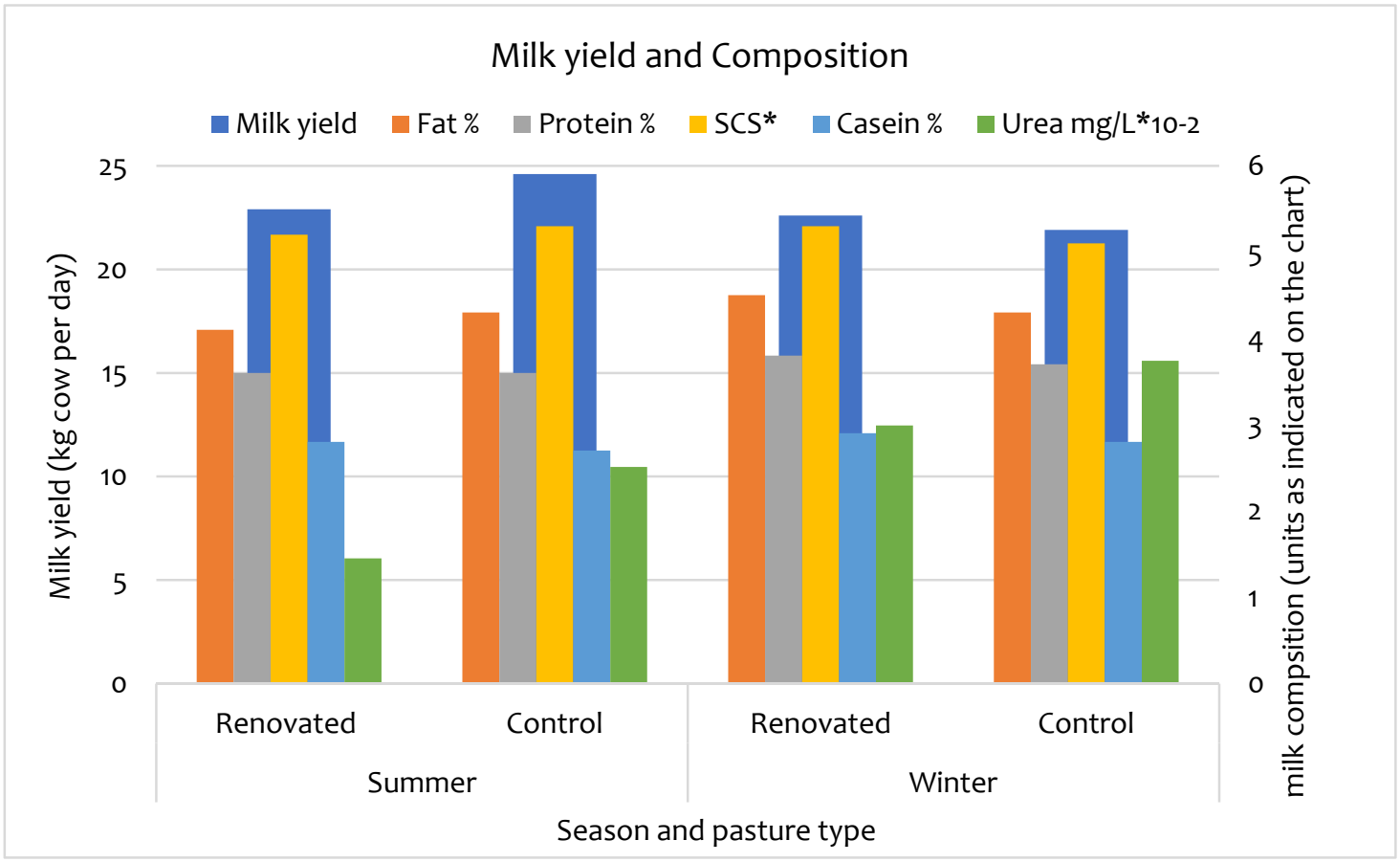

Figure. Effect of season (summer and winter) and grassland type (Renovated and Non-renovated=Control) on milk production and composition. *Somatic Cell Score = log2 (SCC/100) + 3

there was little difference in milk composition, except for lower urea levels from cows on control pastures. Overall there was little difference between the 2 breeds although there was an indication Holstein Friesian cows had a greater response in milk yield to better nutrition from improved pasture silage.

Conclusions

Pasture establishment and growth were successful in the 1st year, leading to higher milk output. However, atypical drought conditions causing poor herbage growth and quality during 2019 confounded results in year 2 with cow grazing unimproved pasture giving more milk. Further monitoring is needed for a true picture of the longer-term potential of this technique.

Imprint

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Does it matter how much forage our dairy cows eat?

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Challenge

Increasing milk production from individual cows is questioned for several reasons; higher yields need greater reliance on purchased concentrate and less use of grazing and other home-grown feeds. The motivation for higher yields is profitability but also better feed efficiency, and it is claimed higher production reduces the environmental impact of every litre of milk produced. However, less is known about the proportion of forage in the cows' diets and how, in practice, this affects profitability and environmental indicators.

Objectives

We set out to assess how the proportion of concentrates in the diet of dairy cows, on traditional combined milk and beef farms in Central Norway, affects both milk production and profitability as well as indicators of environmental impact.

What did we do and what did we find?

Data from 200 dairy farms in Central Norway, recorded by the TINE dairy cooperative advisory service, were categorised into 3 equal sized groups; 'Low', 'Medium' and 'High', according to the level of concentrate feed in the cows' diet. Records covered details of herd feeding, production, animal health and farm accounts for three fiscal years (2014-2016). Data was used to calculate a cradle to farm-gate life cycle assessment to judge the environmental performance. The results are expressed per kg energy corrected milk (ECM) and beef delivered, where 0.42 kg beef meat is equivalent to 1 kg ECM.

Average findings for the 3 groups are summarised in the table above, highlighting differences. Annual concentrate supplementation averaged 2.2 (low), 2.7 (medium) and 3.1(high) metric tons DM per cow with corresponding forage intakes estimated as 63, 56 and 52% of total net energy intake. Whereas average farm size was similar across groups (45 ha), 'Low' farms had lower stocking rate than 'High' and a higher proportion of grazed forage in the diet than either 'Medium' or 'High' farms. Cows in 'High' farms produced about 1 metric ton more energy corrected milk (ECM) annually than cows on 'Low' farms. Milk production in Norway is

Photo: Steffen Adler

Table. Average performance records of farm groups (allocated on concentrate use per cow)

		Concentrate level cows		
	Unit	Low	Medium	High
Number of farms		68	67	68
Concentrate cows	Kg DM/MCU	2173^{c}	2655^{b}	3051a
Forage proportion in the diet	MJ/total MJ	0.63^{a}	0.56^{b}	0.52^{c}
Pasture proportion in the diet	MJ/total MJ	0.10^{a}	0.07^{b}	0.05^{b}
Dairy cows	MCU	29.7^{b}	35.4^{ab}	37.7^{a}
Stocking density	MCU/ha	1.13^{b}	1.26^{ab}	1.29^{a}
Milk quota	1000 L	210.1^{c}	270.3^{b}	293.9^{a}
Quota fill	Proportion	0.93	0.93	0.93
Milk yield per cow	kg ECM/MCU	7868^{c}	8421^{b}	8906^{a}
Meat per total herd size	Kg/MCU cattle	130	135	136
Global warming potential	Kg CO_2-eq/kg ECM	1.42	1.35	1.37
Energy intensity	MJ/kg ECM	4.31	4.10	4.17
Nitrogen intensity	Kg N/kg N	7.00	6.75	6.75
Area of purchased concentrate	ha/ha	0.39^{b}	0.43^{ab}	0.46^{a}
Land occupation	m^2/kg ECM	3.24^{a}	2.88^{b}	2.84^{b}

^{abc} Values within rows with different superscript differs significantly
NEL is net energy lactation. MCU is milking cow unit, equivalent to one dairy cow staying in the herd for 365d, standardised to an annual NEL requirement of 42000 MJ. The whole herd is calculated to MCU.
ECM is energy corrected milk yield
Area of purchased concentrate is the proportion of the total area used on other farms for producing ingredients in purchased concentrate. Total area is the farm area plus area used on other farms for producing imported feed.
Land occupation is the total area used, on and off farm, per kg ECM delivered

restricted by quota, and farms in all three groups achieved a similar 93% quota fill. Thus, it appears that the animal production level and therefore the feeding strategy were closely linked to the quota.

There was little difference with respect to indicators of global warming potential and energy or nitrogen use intensity (Table). Farmers using the least concentrates ('Low') had greater use of local land resources than the two other groups, being less dependent on land away from the farm to grow crops for purchased concentrate. However, the total land occupation per kg milk and meat delivered was greater on 'Low' farms than the two other groups.

Milk and meat subsidies were similar, but the 'Low' group had higher agri-environmental, livestock farming and animal payments per kg milk and beef than the other groups. This, combined with higher milk prices (possibly due to lower cell counts), resulted in 'Low' farms having higher revenues than the other two groups (Figure). Total operating costs were similar although the 'Low' group spent less money on concentrate but more on forage production than the other. Farms in the 'Low' group had lower total production dependent fixed costs, mainly because of the costs involved with forage production and machine maintenance. Overall, 'Low' farms on average performed better financially, with higher gross margin and contributing margins than 'Medium' and 'High' farms (Figure opposite). However, it is important to note that farms' own labour was not recorded and hence not accounted for in this analysis.

Conclusion

Farms in Central Norway, feeding more forage and pasture to their dairy cows, achieved lower milk yield per cow but higher profitability than farms feeding more concentrate feeds, mainly because of more governmental subsidies per kg milk and meat produced. Also, our analysis does not support the general assumption that higher concentrate feeding and milk production lowers global warming potential and energy needed per kg of milk and meat produced compared with more extensive systems.

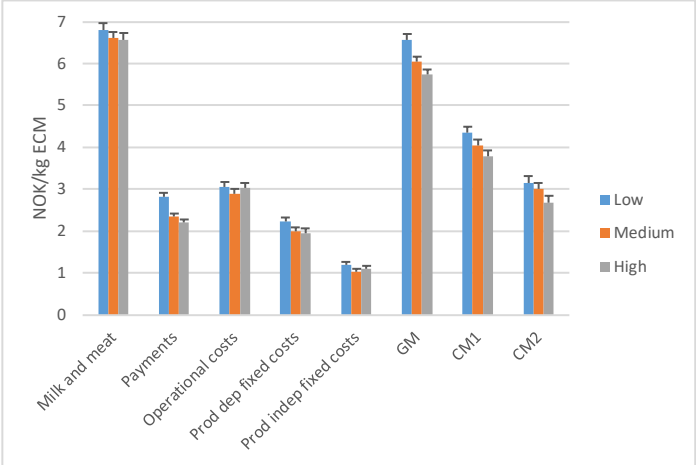

Figure. Comparing the economic performance (NOK/kg ECM delivered) of farm groups. GM, gross margin, is milk and meat sale + governmental payments – Operation costs. CM1, contribution margin, is GM - Production dependent fixed costs. CM2, Contributing margin, is CM1 – Production independent fixed costs.

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Sustainability factors of the Italian dairy rearing system

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About

If we are to improve the production efficiency and environmental sustainability of Italian animal farming, with full regard to animal health and welfare, we need to identify what strategies and changes are appropriate - system analysis is crucial, especially for the dairy sector.

Friesian cows reared on a SusCatt farm. Photo: Dott.ssa Riuzzi Giorgia.

The Italian context: challenges and goals

Although striving to improving environmental, ethical and economic sustainability, the Italian farming system has many obstacles. With more than 60,000,000 inhabitants, the Italian population density is very high, more than 200 people per km2. Furthermore, there are also many farmed animals – almost 6 million beef and dairy cattle, with more than 3.75m in the Po Valley alone. For dairy cows, there are about 3,750,000, nationally 12.4 animals/km2 although about 65% of them are in the Po Valley. In addition there are more than 180m other farmed animals, mainly poultry and pigs, but also goats, sheep, equines, buffalos and rabbits. All in a rearing system that can count on only 12.6m ha of Utilised Agricultural Area (AUU).

Furthermore, even though the production performances have improved, home milk supply does not cover national consumption. More milk is needed but if farms are to increase production it is important they continue to enhance sustainability and meet consumers' increasing attention to product quality and to the way animals are reared.

University of Padova's goals within SusCatt fulfils this needs and expectations. Indeed, we aim to provide Po Valley production systems with new perspectives, to evolve competitive and sustainable strategies from an environmental, ethical and economic point of view. In particular, the research focuses on evaluating and promoting new feeding approaches moving towards a circular economy, based on a greater use of home-grown feeds, especially hay, and by-products coming from other industries.

Results

SusCatt activities' will demonstrate how to improve both animal health and welfare and dairy product quality, yet reducing farms' environmental impact by using more home-grown forages, especially hay. This a win-win - these forages are not only more suitable for a healthy rumen activity but, allowing farmers to exploit local resources, they reduce their reliance on imported products or on locally produced feeds which are hard to grow. Moving towards a circular economy scenario that is not only sustainable from an environmental, ethical and, possibly, economic point of view, but also matches with the current consumer's expectations.

SusCatt partners visiting a farm in Padova.

Brown cows reared on a SusCatt farm. Photo: Dott.ssa Riuzzi Giorgia.

Imprint

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

What do our cows eat? – Using technology to authenticate forage-based milk

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About

To this day, details of feeding regime are not mandatory declarations for dairy products sold in EU. However, they are very distinctive in terms of geographic area and the production process; both of which influence product quality. Indeed, consumers should be able to identify production chains, especially if seeking sustainable, animal-friendly diets.

Challenge

Comprehensive barcode labelling throughout the dairy supply chain would be useful for consumers, legislators, processors and producers. It would avoid mislabelling and frauds (even if unintentional) and allow tracing physical-chemical traits of any product to a given production chain.

We know that cows' feeding is the main factor that affects milk's nutritional quality. Milk composition (in terms of fatty acids, vitamins, organic acids, etc.) and flavour are strongly influenced by the botanical origin and conservation of the forage our animals eat.

Much research has focused on assessing the finer details of milk composition, to identify bioactive compounds as potentially useful markers of milk origin. This includes a study of the unique chemical fingerprints left by specific cellular metabolic processes - a metabolomics approach. This promising method provides a detailed picture of food composition, allowing simultaneous characterisation of many compounds in complex biological matrices and is proving useful as a rapid, accurate tool for milk authentication. More recently, DART-HRMS has been developed, coupling two cutting-edge analytical techniques (**D**irect **A**nalysis in **R**eal **T**ime and **H**igh **R**esolution **M**ass **S**pectrometry); allowing even quicker results with simple, accurate analysis.

The three main feeding systems are based on maize (top), cereals other than maize/hays (middle) and permanent meadow for hay (bottom). Photo: Dr. Severino Segato.

Objective

We evaluated the accuracy and reliability of DART-HRMS to assess the nutritional profile of milk from farms feeding different forages (maize silage and hays) and to identify useful, reliable biomarkers of milk origin.

What did we do?

The diets used on the farms involved were typical of the main agronomic dairy systems in the Pò Valley. They could be grouped into 3 systems, roughly described as: (1) maize silage, typical of intensive dairy farms; (2) hays and cereals other than maize, representing farms with some permanent meadow and downsizing maize monoculture by applying crop rotation to arable land; (3) hays, representing a system preserving permanent meadow and enhancing environmental sustainability.

In total, 14 specialized dairy farms, all in the Veneto region, were involved: 6 adopting the maize-based diet, 5 feeding other cereals and hays, and 3 using mainly hays. Over 2018, 70 raw bulk milk samples were collected (5 samples/farm) and analysed by using a DART-HRMS.

The statistical approach, based on a mid-level data fusion, identified the most informative chemical variables and proved that DART-HRMS has a powerful and reliable capacity to authenticate milk samples according to the feeding management.

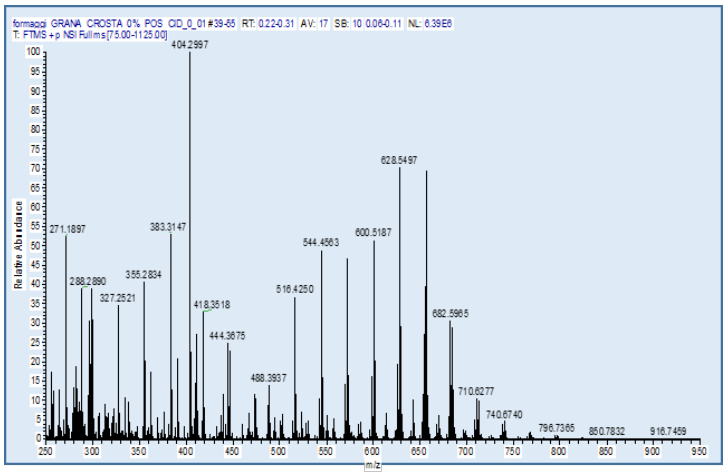
Results

A pool of 50 informative biomarkers were identified and correlated with the forage fed. The most relevant metabolites were: carbohydrates (lactate), amino acids (glutamate) and other hydrophilic compounds (hydroxycinnamic acid) for maize; phosphoric compounds (creatinine, methyl 2-furoate), fatty acids C18:2-, C20:2- and C22:2- and trace of low molecular weight substances such as norgramine for other cereals, fatty acid (palmitate), flavonoids and lipophilic compounds for the sole use of hays.

We found that DART-HRMS analysis is reliable to discriminate the forage-based systems in this on-farm study.

Conclusions

This study confirmed that the botanical origin and conservation of forages fed to cows strongly influence the milk metabolomic profile. As a consequence, it should offer a tool to allow authenticate dairy production chains according to the feeding regime adopted on the farms. DART-HRMS proved to be a fast, accurate and powerful tool to perform such analysis.



Fingerprinting of milk after acquisition by DART-HRMS analysis..

Cow's diet affects milk metabolomic profile. Photo: Dr Riuzzi Giorgia.

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Assessing diverse forages to reduce the environmental impact of grazing dairy cows

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About

Grazing dairy systems are the most cost-effective form of ruminant production, however, enteric methane produced by the cows is a major source of agricultural greenhouse gases.

We asked ourselves if diverse pastures, particularly when including tannin rich forages, could reduce methane emissions while maintaining productivity. Thus, we compared the performance and methane emissions of grazing dairy cows on two forage mixtures with contrasting sward diversity.

Jersey cow with SF_6 equipment grazing on diverse pasture.
Photo: Carsten Malisch

Challenge and objectives

Although the benefits of grazing dairy systems have been widely proven and customer preference for pasture-based milk and dairy products is increasing, information on methane emissions from cows grazing mixed swards, including tannin-rich herbs, is scarce. The existing predisposition was, that due to poorer efficiency, methane emissions per litre of milk would increase if cows graze rather than being housed. On the other hand, several herbs have been hypothesized to reduce rumen methane production, while simultaneously providing ecosystem services - by enhancing carbon sequestration and biodiversity.

Our goal at CAU Kiel was to find out if we could create herb-rich, diverse pastures for intensive grazing by dairy cows, that might combine all these benefits to produce environmentally friendly, high quality milk with lower methane emissions.

What did we do?

In the experiment, we measured enteric methane and milk yield from 24 mature, spring-calving Jersey cows grazing two perennial mixed swards with contrasting degree of diversity at peak (May) and late lactation (September). The swards were: i) a relatively simple mix of perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) and ii) a diverse mixture with eight sown species, which also included: red clover (*Trifolium pratense*), birdsfoot trefoil (*Lotus corniculatus*), salad burnet (*Sanguisorba minor*), chicory (*Cichorium intybus*); narrow leafed plantain (*Plantago lanceolata*) and caraway (*Carum carvi*).

Throughout the study, cows were milked twice a day (0600 and 1600 h) and individual milk yield was recorded automatically, with subsamples analysed for quality. Enteric methane collection was measured using the sulphur hexafluoride (SF_6) tracer technique, adapted

for a 4-day collection period. Forage uptake was estimated from pre- and post-grazing herbage height, measured by an electronic raising platemeter (Grasshopper, True North Technologies, Shannon, Ireland), and by cutting ten randomly chosen 0.25 m² quadrats per plot to a height of 4 cm, which were subsequently sorted for botanic composition.

Diverse pastures can provide comparable energy yields to binary mixtures

The nutritional quality of both herbage mixtures was very good throughout, with energy concentrations of 7.7 and 6.9 MJ NEL / kg DM for the simple mixture and 7.5 and 6.7 MJ NEL / kg DM for the diverse mixtures, for late spring and late summer, respectively. Herbs accounted for up to 24% of the diverse mixture in late spring, while in autumn particularly red clover boosted its share to 41%. The proportion of ryegrass was always twice as high in simple compared to diverse mixtures with 90% in spring and 55% in autumn. Unfortunately, the proportion of tannin rich herbs (birdsfoot trefoil and salad burnet) in the mixed swards were generally low.

Milk yields and methane emissions are excellent throughout

Milk yield (and calculated energy corrected milk yields or ECM) were very high for both systems, reaching 30 kg ECM in late spring and 23 kg ECM per cow per day in autumn. On average, cows grazing diverse pasture gave more milk - an extra 1kg ECM per cow and day in both early and late lactation, compared with cows grazing the ryegrass/clover swards.

Compared to published figures for grazing jersey cows, daily methane emissions here were low for both systems, although slightly higher from the diverse mixtures compared to the simple mixed swards (on average 221 g for binary vs 260 g CH_4/cow/day for the diverse mixtures). Methane intensity relative to milk yield in this experiment (between 8.3 to 10.4 g CH_4/kg ECM) was also much lower than the average of 17g / kg ECM, previously reported for grazing Jersey cows. This can largely be explained by unusually high milk yields in this study as a consequence of intensive use of excellent quality forages.

Conclusion

Well managed, efficient organic dairying appears to have very low methane emissions. Adding a low level of forbs to swards provides little additional benefits as these herbs are not competitive under intensive grazing management, although might be appropriate for mixtures with lower use intensity.

Binary (top) and diverse (bottom) mixtures constituting the two treatments. Lindhof experimental farm, Kiel University. Photo: Cecilia Loza

Imprint

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TECHNICAL NOTE

SusCatt - Increasing productivity, resource efficiency and product quality to increase the economic competitiveness of forage and grazing based cattle production systems

Building the market for *Grass-fed*

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Challenge

There is no denying beef farming is a hot-topic with overwhelming negative associations for many consumers. However, not all beef is the same and growing evidence supports the many benefits grass-fed offers – not least for animal welfare, positive for environment and consumers' health – not to mention economic sense for farmers. The more we sell, the greater the cumulative benefit from these positive impacts.

Organic beef sirloin. Photo: Peelham Farm.

Background

There's no denying the positive messages grass-fed offers farmers, cattle, environment, consumers and society at large, however this note does not cover such details – these can be found on the Pasture Fed Livestock Association or PFLA website, covering: farm returns, nutritional benefits, animal welfare and environmental impact. Instead, we explore how farmers might encourage more consumers to buy grass-fed - another note in the series, targeting consumers and policy makers, summarises these benefits.

Aim

If we are to expand grass-fed production and reap the many benefits this offers society; we need to develop the market. Understanding which provenance claims are important to consumers, how much they know about different farming systems and what currently stops them buying grass-fed will all help. This note gives a brief outline of some of this information, which might be helpful to build future demand – we need to identify relevant messages.

What did we do?

Information was gathered in 2 ways: i) an on-line poll to judge consumers' knowledge of certified grass-fed beef and its potential health benefits and ii) a review of published academic papers on triggers for consumer meat purchasing decisions.

What did we learn?

The online poll reached 138 beef buying consumers across the UK in 2017, mostly in SE and SW England. As a baseline, about 25% were aware of the PFLA, 19% claimed to have bought certified meat and 28% were aware of its potential health benefits compared with other beef. Encouragingly, after reading information about health benefits from enhanced omega-3 content, 60% stated they [definitely or probably] would buy grass-fed and 43% were willing to pay a premium. However, there is a BUT - bas to why they hadn't before; which was dominated by a combination of 'sourcing' (52%) and 'too expensive' (43%). Products need to be accessible or visible and, whilst we can't price match commodity products, we can educate consumers about true

production costs and the principle of consuming less-but-better dairy and meat.

The academic papers were less focused on grass-fed but also quite revealing, however findings need to be viewed with care. Studies were conducted in many different countries over a number of years and we do know that decisions on food purchase are not only complex, but attitudes or expectations vary and also change over time, influenced by topical issues.

One disappointing issue with all the studies, although 'grass-fed', free-range' or 'pasture access' were generally ranked highly overall, none of the papers described, explored or explained what these terms mean - I doubt if any relate to 100% forage feeding, in consumers' minds. That said, more positive lessons can be taken from the fact most other priorities reported to be important can, or could, be applied to grass-fed meat and milk. There were common threads reinforced by many studies, many of which can be found in the table below, taken from fairly recent review by an Irish group, covering 15 different consumer studies – only 3 of the top 12 priorities don't directly relate to grass-fed.

Ranking of attributes and their potential for *grass-fed* – adapted from Henchion et al 2017 'Beef quality attributes: a systematic review of consumer perspectives'

Quality attributes	Overall ranking	Applicable to *grass-fed*
origin / local	1	potentially
price	2	no
certification, labels, brand info	3	yes
visible fat	4	yes
flavour	5	yes
animal welfare	6	yes
production system/feeding	7	yes
freshness/wholesomeness/shelf life	8	no
natural (GM & hormone free)	9	yes
tenderness	10	no
health, nutrition, body weight	11	yes
meat colour	12	yes

Another relevant point echoed in many studies was the importance to consumers of certification or independent verification of provenance, to instil credibility to claims. However, they also report messages or labelling needs to be simple & understandable.

So what

Looking into the scope of using this literature to enhance sales of grass-fed products shows a major challenge. Any delivery to potential customers has to be simple and understandable but at the same time needs to convey complex messages about the production systems.

Crosslane cattle herd. Photo: Crosslane Organic Farm.

Guidance suggests:

- Working on educating consumers about:
  - benefits grass-fed offers over 'mainstream' products, linked to
    - +Nutritional
    - +Environmental
    - +Welfare
  - True cost of production
  - Less-but-better principles
- Make products accessible and visible with clear certification labelling
- As the market builds, encourage more farmers to get involved, expanding grassland areas – possibly including short term leys in arable rotations.

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